Q&A update for Constellation-X mandel RFI – January 08, 2007

The following questions (with answers) have been asked of the program by various participants; all are being posted on the project website at

http:///www.tbd.gsfc.nasa.gov

For clarity, we separate these Q&A into programmatic and technical sections

1. Programmatic

A. Can you share with us NASA's procurement strategy associated with the Constellation-X Mission? Does NASA intend to be the integrator for the three X-ray telescopes? If not, what type of vendor will be the prime? How will the work be divided?

The current baseline for the Flight Mirror Assembly is a prime contractor for both mirror fabrication and mirror integration & alignment into the four telescope assemblies. However, an option for performing some or all of this in-house is under investigation.

B. Regarding Mandrel procurement:

Will the Mandrel procurement be a "build to print" based on NASA's System Level Analysis or based on a downselected prime contractor?

For the purposes of the RFI we are asking that the 'build to NASA print' option be assumed.

C. How many vendors have been issued the RFI for the mandrels? How many are Domestic vendors?

There are several domestic and at least one foreign vendor interested in the RFI.

D. Is there an existing metrology prescription/test procedure associated with previous Zeiss polishing of Constellation-X mandrels delivered by Schott? Can you describe or point us to literature describing their effort?

Zeiss have published SPIE articles on their work for Constellation-X project; we refer you to these. Also, MSFC has performed acceptance metrology on these and other mandrels, their work also has been published:

…spie xxxx

E. Regarding mandrel delivery, if six mandrels a week becomes your requirement, what is the maximum number of vendors you will contract with?

Responses from the RFI will help determine the number of mandrel vendors required. We currently envision no more than two mandrel vendors, but recognize the potential

advantages of a single proven vendor.

F. After the mandrels are produced, how will the mirror segments be manufactured? How many vendors will be chosen to manufacture the mirror segments?

TBD - This is also part of the in-house/out-of-house trade we have not completed. Again we think one vendor would be best here.

2. Technical

A. What is the reference power spectral density (PSD) [ Fig. 2-2 of the RFI] based on? On an existing mandrel or theoretical calculations? The slopes of up to -7 are very challenging.

The reference PSD is actually based on a composite fit to the technology development mirrors made from the current mandrels in use. The fitted PSD for the segment is scaled (reduced) proportionately to the portion of the error budget which has been allocated for mandrel fabrication errors.

The mandrel is treated to promote release after thermal forming and is rough at high spatial frequencies (spatial periods below ~2mm). The glass being formed is intrinsically smooth at high frequencies and so the mandrel is not directly required to be smooth at high frequencies as delivered. We documented a requirement of ~1nm rms simply as that is what we know will work with the current process. It may be that rougher mandrels would be consistent with the current process.

To aid responders, we now provide a PSD of mandrels in use and integrated (axial only) rms statistics over bandpasses. While we are sure that these mandrels are not limiting performance, we do not have enough information to fully specify mandrels. PSD slopes are still high for these mandrels in some spatial frequency ranges, but these were not difficult to manufacture.

The (axial, one-dimensional) PSD shown here is based on papers by Eugene Church and has the form
PSD = (a/[1+(b f)^2]^(c/2)
where a, and b  scalar constants have dimensions mm^3 and mm respectively; c is the (dimensionless) slope.

A fit to the mandrel PSD using a low and high frequency portion results in these values:

**Table 1:  Example mandrel PSD fit coefficients for the example mandrel PSD in Fig. 1.**

| | P1 (low) | P2 (high) | units |
|---|---|---|---|
| a | 1.0E-06 | 1.0E-11 | mm^3 |
| b | 90 | 5 | mm |
| c | 5 | 2 | - none - |

Integration of this model over the bands 100-1mm and 1-0.001mm gives rms surface error values of 33nm and 0.6nm respectively.

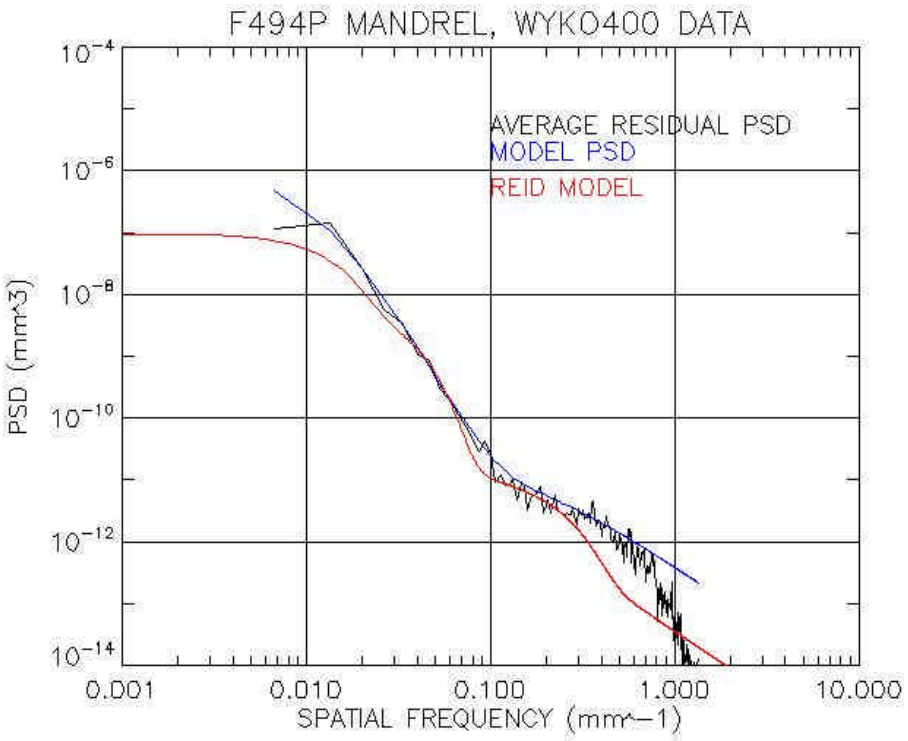


**Figure 1: Axial PSD from the RFI, scaled from that fitted from mirror segment data on multiple mirror segments (red, "Reid Model") and example "Average residual PSD" mandrel in use (black) with model (blue). Modeled performance of perfectly formed mirror segments from this mandrel is acceptable.**